Time-dependent influence of supranutritional organically bound selenium on selenium accumulation in growing wether lambs

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ABSTRACT: Crossbred wethers (n = 36; BW = 36.0 kg; SD = 3.4) were used to assess the time-dependent influence of supranutritional organically bound Se on Se accumulation. Four wethers were slaughtered before the trial began (d 0). The remaining wethers were fed diets containing adequate (0.2 μg of Se/g of DM) or supranutritional Se (2.9 μg of Se/g of DM; in the form of high-Se wheat grain) for 14, 28, 42, or 56 d before slaughter (four wethers per Se treatment at each slaughter day). The DMI was set at 3.1% of BW and adjusted weekly based on a targeted ADG of 150 g. Daily Se intake by wethers fed the adequate and supranutritional Se diets ranged from 5.3 to 5.9, and 79.0 to 95.0 μg of Se/kg of BW, respectively, and did not differ (P = 0.84 to 0.99) between slaughter day groups within Se treatment. Neither Se treatment nor Se treatment × slaughter day interactions were significant for BW, G:F, or liver, kidneys, and spleen weights (P = 0.06 to 0.84). Within the supranutritional Se treatment, Se contents of most organs and tissues from wethers slaughtered on d 14, 28, 42, and 56 were nearly twice the concentrations ($P < 0.01$) of wethers slaughtered on d 0. When regressed against the number of days the wethers were fed supranutritional Se, Se concentrations increased ($P < 0.001$) cubically in kidneys and plasma, quadratically in duodenum, lung, liver, and spleen, and linearly in heart, muscle, and wool. For total Se in kidneys, liver, and spleen, the response was quadratic ($P < 0.03$). Excluding skeletal muscle, heart, and wool, Se in other organs and tissues reached apparent steady-state concentrations 14 to 28 d after commencement of supranutritional Se diets. Selenium concentrations in skeletal muscle accumulated in a linear manner ($P < 0.001$) throughout the 56-d feeding period. High-Se grains can be used strategically to deliver supranutritional Se and rapidly enhance Se depots in sheep, a task that does not seem attainable with Se salts. Furthermore, a 100-g portion of uncooked loin (LM) from the wethers fed supranutritional Se contained 196 to 250% of the recommended Se requirement for humans.

Key Words: Muscle, Organically Bound, Selenium, Sheep, Supranutritional, Wheat

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Introduction

In North America range sheep operations, opportunities to provide supplemental Se are limited and depend on animal location (e.g., extensive rangeland vs. dry lot or small pasture). When an opportunity to supplement occurs, the tendency is to provide supranational amounts of Se (in excess of the daily requirement; >0.3 μg Se/g DM; NRC, 1985). Sodium selenate and selenite (Se salts) are the most common chemical forms used to enhance dietary Se; however, the use of manufactured Se sources (including Se-enriched yeast) is regulated, and dietary inclusion cannot exceed the equivalent of 0.3 μg of Se·g of DM^{-1}·d^{-1} (FDA, 2004). Currently, the use of feedstuffs naturally high in Se to deliver supranutritional Se is not regulated. The predominant chemical form of Se in high-Se grains and hays seems to be selenomethionine, an organically bound source of Se (Wu et al., 1997; Whanger, 2002).

Because of its interchangeability with methionine during protein synthesis (Waschulewski and Sunde, 1988; Butler et al., 1989), the half-life of Se in selenomethionine in humans is twice that of Se in selenite (Swanson et al., 1991). Supranutritional Se provided as high-Se wheat grain results in greater Se accumulation in skeletal muscle of finishing steers (Lawler et al., 2004) and mature ewes (van Ryssen et al., 1989) relative to when Se salts are fed. The strategic short-term use of high Se grains could provide a viable means to rapidly enhance Se depots in sheep, and improve the

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nutritive quality of skeletal muscle. Nonetheless, the effects of feeding supranutritional levels of organically bound Se on tissue Se distribution in lambs are unknown. Thus, the objective of this study was to determine the time-dependent effect of supranutritional Se, fed as a naturally high-Se wheat grain, on Se accumulation in growing wether lambs.

Materials and Methods

Animals

Crossbred wethers (Polypay × Suffolk and Columbia; n = 36; BW = 36.0 kg; SD = 3.4 kg) were weaned, placed in a dry-lot facility, and fed 0.5 kg (as-fed basis) of whole corn daily, with ad libitum access to long-stemmed alfalfa hay and water for 7 d. The wethers were then moved indoors to individual pens (0.8 m × 2.4 m), with ad libitum access to water and assigned to nine groups (four wethers per group), each with a numerically similar group mean BW (36.0 kg; within group CV = 10.3%; between group CV = 1.0%). One group was randomly selected to be slaughtered at trial commencement (d 0). Slaughter days occurring 14, 28, 42, or 56 d after commencement of treatment were assigned randomly to the remaining groups, such that two groups were slaughtered each day. Within slaughter day, an adequate or supranutritional Se treatment diet (described below) was assigned randomly. As such, there were four individually treated wethers per treatment for each slaughter day. The U.S. Sheep Experiment Station Institutional Animal Care and Use Committee (Dubois, ID) reviewed and approved use of the wethers as described herein.

Treatment Diets and Delivery

Two diets (Table 1) were formulated to provide either an adequate (0.2 μg of Se/g of DM; NRC, 1985) or a supranutritional Se diet (2.9 μg of Se/g of DM). The major ingredients used for the experimental diets were purchased locally (Terreton, ID). High-Se rolled wheat grain (6.4 μg of Se/g of DM), grown near Pierre, SD, replaced a portion of the locally purchased wheat (0.1 μg of Se/g of DM) to develop the supranutritional Se diet. Before starting the experiment, feedstuffs to be used were individually subsampled (n = 20), pooled, and analyzed for ADF (Van Soest et al., 1991; Ankom 200 fiber analyzer; Ankom Technology, Fairport, NY), CP, Ca, P (AOAC, 1997), and Se (described below). Treatment diets were individually fed at 0700 and 1600 daily according to the number of days before scheduled slaughter. Dry matter intakes were set at 3.1% of BW, and were adjusted weekly based on a targeted ADG of 150 g. Orts were collected and weighed daily at 0645.

Sample Collection and Se Analysis

Feed and water were removed from the wethers 12 h before each slaughter day. A jugular blood sample (Corvac serum separator, Tyco Healthcare, Mansfield, MA) and BW were obtained, wethers were subsequently stunned with a captive bolt pistol (Entwistle guns, Lancs., England, U.K.) and exsanguinated. Approximately 10 min after exsanguination, the kidneys, liver, and spleen were removed and weighed. Four samples, approximately 1-cm^3, were excised from the heart, kidneys, liver, left lung, skeletal muscle (LM), spleen, and duodenum (approximately 1 cm^2), immediately wrapped in aluminum foil, stored in liquid N_2 for 30 min, lyophilized (48 h), and transferred to a freezer (–65°C) until subsequent Se analysis. In addition, two approximately 1-cm diameter areas of wool were removed at the epidermal surface, above the 13th rib and directly over the spine, and stored. The Se concentrations of all samples were determined using inductively coupled plasma-mass spectrometry after acid digestion (minimum detection limit = 10 ng/mL; interassay CV = <7% and intraassay CV = <4%; Utah Veterinary Diagnostic Laboratory, Logan). Briefly, samples were digested in heated nitric acid and diluted with ultrapure water to a final nitric acid concentration of 5% (vol/vol; similar matrix of standards). The Se content of the diluted digests was calculated from a series of known standard preparations (Spex Certiprep, Metuchen, NJ).

Table 1. Feedstuff and nutrient composition (DM basis) of treatment diets fed to wether lambs

	Treatment diets	
Item	Adequate Se	Supranutritional Se
Feedstuffs		
High Se rolled wheat, %[a]	—	42.2
Adequate Se rolled wheat, %[b]	50.7	5.6
Alfalfa, %	30.6	31.9
Whole oats, %	—	3.7
Whole corn, %	11.4	10.2
CSB, %[c]	6.0	6.0
Soybean meal, %	0.9	—
Limestone, %	0.2	0.2
Trace mineral salt, %[d]	0.2	0.2
Lasalocid, mg·wether^{-1}·d^{-1}[e]	45.0	45.0
Nutrients[f]		
Se, μg/g	0.2	2.9
CP, %	15.7	
TDN, %	76.1	
Ca, %	0.6	
P, %	0.3	

[a]Wheat was grown near Pierre, SD; Se = 6.4 μg/g, DM basis.
[b]Wheat was purchased in Mud Lake, ID; Se = 0.1 μg/g, DM basis.
[c]Sugarbeet concentrated separator by-product.
[d]Redmond NTM (natural trace mineral) salt, Redmond, UT. Composition on a DM basis: NaCl = 95%; Ca = 0.55%; Cu = 0.0007%; I = 0.002%; Fe = 0.07%; Mg = 0.09%; Mn = 0.0007%; P = 0.05%; K = 0.12%; S = 0.13%; Se = not detectable.
[e]Bovatec 68, Alpharma, Fort Lee, NJ.
[f]Nutrient content of the diets are based on the sum nutrient contribution of each feedstuff formulated into the diet. Feedstuffs were analyzed separately for respective nutrient concentrations.

Table 2. Selenium intake by wethers fed diets containing adequate or supranutritional Se for 14, 28, 42, or 56 d[a]

	Slaughter day[b]					Regression[c]	
Selenium intake	14	28	42	56	SE	Effect	*P*-value
BW basis, μg kg^{-1} d^{-1}[d]							
Se adequate	5.9	5.7	5.9	5.3	0.3	—	0.28
Supranutritional Se	95.0	96.3	79.0	89.2	3.9	Cubic	0.04
SE	3.8	3.8	3.6	3.8			
P-value[e]	<0.001	<0.001	<0.001	<0.001			
Total basis, mg[f]							
Se adequate	3.05	5.86	9.42	12.31	0.47	Linear	<0.001
Supranutritional Se	47.77	96.42	138.24	195.37	5.61	Linear	<0.001
SE	5.87	5.87	5.87	5.87			
P-value[e]	<0.001	<0.001	<0.001	<0.001			

[a]Adequate and supranutritional Se treatment diets contained 0.22 and 2.86 μg of Se/kg (DM basis), respectively.
[b]Number of days Se treatments were fed before slaughter; experimental units were four wethers per treatment for each slaughter day.
[c]Relationship between Se intake and total days supranutritional Se diet was fed (slaughter day).
[d]Daily Se intake calculated from the 14 d before each slaughter day.
[e]Adequate vs. supranutritional Se (LSD).
[f]Total Se intake calculated from total days of Se treatment for each slaughter group.

Statistical Analyses

Response variables were Se and DMI, ADG, and G:F for each wether calculated from the 14-d period before the corresponding slaughter day; the total cumulative Se intakes calculated for each wether from the start of the trial to corresponding slaughter day; and organ and tissue Se contents. Because growth and physiological development is continuous in growing lambs, and these changes may influence Se distribution, a term for the Se treatment × slaughter day interaction was included in the data analysis. Data were treated as repeated measures and analyzed using the mixed models procedure of SAS (covariance structure = autoregressive order 1; v. 8.2; SAS Inst., Inc., Cary, NC). When the Se treatment × slaughter day interaction was significant ($P < 0.05$), only mean comparisons of biological significance were conducted. Specifically, treatment differences were determined only within each slaughter date, and slaughter day differences were determined only within each Se treatment. All means were separated ($P < 0.05$) using preplanned pairwise comparisons (LSD). In addition, individual wether (not least squares means) organ and tissue Se contents were regressed against the number of days on Se treatment (day of slaughter) to visualize apparent Se steady-state trends, if they occurred. When only a slaughter day effect was significant ($P < 0.05$; DMI, ADG, and G:F), the individual wether responses were regressed against the number of days on Se treatment (day of slaughter) to assess overall growth and efficiency trends.

Results

The Se treatment × day of slaughter interaction was significant for daily and total Se consumed ($P < 0.005$; Table 2). The daily Se intake of wethers fed the adequate Se diets ranged from 5.3 to 5.9 μg of Se/kg BW and did not differ ($P = 0.84$ to 0.99) between slaughter day groups. The daily Se intake of wethers fed supranutritional Se was least ($P < 0.004$) on d 42 and not different for d 14, 28, and 56. Within each slaughter day, wethers fed supranutritional Se diets consumed 13 to 17 times more ($P < 0.001$) Se than did wethers fed the adequate Se diets. Total Se consumed within each treatment increased linearly ($P < 0.001$) for each consecutive slaughter day group, and total Se consumed was consistently greater ($P < 0.001$) for supranutritional vs. adequate Se-fed wethers.

The treatment × day of slaughter interaction was significant ($P = 0.03$) for DMI (percentage of BW). This effect was due to one supranutritional Se-fed wether in the d-42 slaughter group not consuming feed for 2 d. As such, wethers fed the adequate diet had greater DMI than did wethers fed supranutritional Se for the d-42 slaughter group (3.3 vs. 2.8% of BW; SE = 0.14). Neither Se treatment effects ($P = 0.58$ to 0.99) nor the treatment × day of slaughter interactions ($P = 0.06$ to 0.12) were significant for the other performance measures or organ weights. The least squares means for BW, DMI, ADG, and G:F, and kidneys, liver, and spleen weights are presented in Table 3 for each slaughter day group, with the effects of Se treatment removed. Body, liver, and spleen, but not kidney ($P = 0.12$), weights increased linearly ($P < 0.01$), and DMI (percentage of BW) decreased linearly ($P < 0.02$) for each consecutive slaughter day group.

The Se treatment × day of slaughter interactions were significant ($P < 0.001$) for the kidneys, liver, and spleen Se concentrations and total Se (Figure 1), and duodenum, heart, lung, muscle, plasma, and wool Se concentrations (Figure 2). Within slaughter d 14, 28, 42, and 56, the Se content of all tissues and organs was greater ($P < 0.05$) for the supranutritional Se than for the ade-

Table 3. Performance measures and organ weights of wether lambs slaughtered on d 0, 14, 28, 42, and 56 of the trial

	Slaughter day[a]						Regression[b]	
Trait	0	14	28	42	56	SE	Effect	*P*-value
BW, kg	35.7	39.3	39.2	41.8	43.9	1.6	Linear	0.01
DMI, % of BW[c]	—	3.3	3.3	3.0	3.0	0.1	Linear	0.02
ADG, kg[c]	—	0.179	0.149	0.135	0.138	0.032	—	0.35
G:F[c]	—	0.149	0.121	0.101	0.106	0.025	—	0.19
Organ/ weights[d]								
Liver, kg	0.589	0.627	0.676	0.651	0.703	0.033	Linear	0.01
Kidneys, kg	0.096	0.099	0.101	0.103	0.108	0.005	—	0.12
Spleen, kg	0.064	0.070	0.072	0.074	0.087	0.005	Linear	0.001

[a]n = 4 for d 0, and n = 8 for d 14, 28, 42, and 56.
[b]Relationship between the individual performance measures or organ weights, and slaughter day.
[c]Performance measures calculated from the 14 d before each slaughter day.
[d]Organ weights are expressed on an "as-is" basis and were obtained 10 min after exsanguination.

quate Se treatment. For wethers fed the adequate Se treatment, Se contents of the kidneys, spleen, and lung increased slightly ($P < 0.04$) for each consecutive slaughter group, but did not differ ($P = 0.06$ to 0.95) for other tissues and organs. Within the supranutritional Se treatment, the duration of dietary Se exposure influenced Se accumulation. Compared with the wethers slaughtered on d 0, Se contents of kidneys, liver, and spleen from the wethers assigned to subsequent slaughter day groups were more than two times greater ($P < 0.001$). When regressed against day of slaughter, Se concentration increased ($P < 0.001$) quadratically for liver, and cubically for kidneys and spleen; for total Se, the response was quadratic ($P < 0.03$) for each of these organs. The Se concentrations of duodenum, heart, lung, muscle, plasma, and wool also were least in wethers slaughtered on d 0 compared with wethers slaughtered on subsequent days ($P < 0.001$). When regressed against day of slaughter, Se concentration increased ($P < 0.002$) linearly in heart, muscle, and wool, quadratically in duodenum and lung, and cubically in plasma. The cubic responses are most likely due to the sensitivity of kidney, spleen, and plasma to the decrease in total Se intake observed in the d-42 slaughter group.

Discussion

High-Se wheat grain is an effective vehicle for delivering supranutritional levels of organically bound Se for rapid enhancement of Se status in growing lambs, without adversely influencing performance. Consumption of high-Se wheat, providing 2.9 μg of Se·g of $DM^{-1}·d^{-1}$, resulted in a 2.1, 3.7, 4.5, and 5.9 times greater skeletal muscle Se within 14, 28, 42, and 56 d, respectively, relative to d 0. Such enhancement of muscle Se could provide endogenous Se stores at a level to offset a potential Se deficiency in sheep grazing Se-deficient rangelands.

Based on the linear increase in skeletal muscle Se of wethers fed high-Se wheat grain, one might assume that an apparent steady state was not achieved within 56 d. Similarly, Waschulewski and Sunde (1988) reported muscle Se concentration of rats fed a supranutritional selenomethionine diet also increased linearly over a 20-d trial period. Although only an endpoint response was measured, van Ryssen et al. (1989; mature ewes), Hintze et al. (2002; growing steers), and Lawler et al. (2004; finishing steers) reported that Se concentration of skeletal muscle increased 2.6, 4.2, and 3.3 times when high-Se wheat was included in the diet at 1.0, 11.9, and 2.8 μg of Se·g of $DM^{-1}·d^{-1}$, respectively, for approximately 100 to 120 d. These studies, in combination with the current results, support the findings of Beilstein and Whanger (1986, 1988) and Whanger and Butler (1988) that skeletal muscle mass contained more total Se than did other tissue masses in the body (rat), and responded the greatest to supranutritional Se when provided as selenomethionine. In contrast to skeletal muscle, the Se content of duodenum, plasma, and kidneys seemed to reach steady state within 14 d, and liver, spleen, and lung within 28 d after commencing the supranutritional Se treatment. van Ryssen et al. (1989) observed plasma Se to reach steady state within 20 d in mature ewes fed 1.0 μg of Se/g of DM as high-Se wheat. Waschulewski and Sunde (1988) reported similar responses in plasma and liver of rats fed selenomethionine (0.5 μg of Se/g of diet; as-fed basis); however, liver Se seemed to reach apparent steady state sooner than plasma (6 vs. 13 d, respectively). Based on previous measurements (Wu et al., 1997; Whanger, 2002), the predominant chemical form of Se in the high-Se wheat fed in the present study was selenomethionine.

Unlike all other amino acid forms of Se and their sulfur analogues, selenomethionine is interchangeable with methionine during translation (Waschulewski and Sunde, 1988; Butler et al., 1989). Methionyl-tRNA synthetase will aminoacylate $tRNA^{Met}$ with selenomethionine; however, the formation of methionyl-$tRNA^{Met}$ is slightly favored (Hoffman et al., 1970; McConnell and Hoffman, 1972). Because of this unique interchangeability with methionine, Se as selenomethionine can be

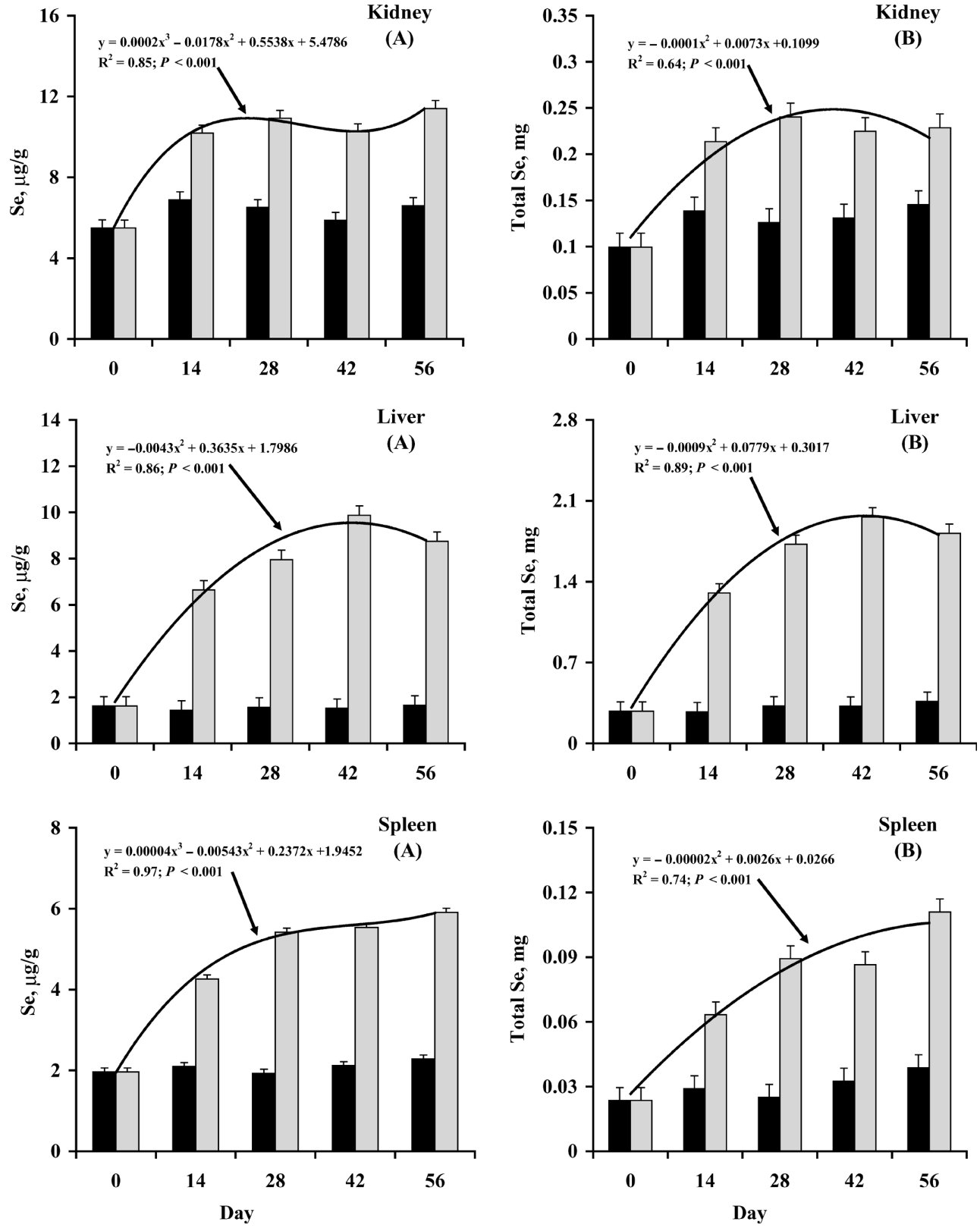

Figure 1. Selenium concentration (A) and total Se (B; organ weight × Se concentration) for kidneys, liver, and spleen of wether lambs fed an adequate Se (■; 0.2 μg of Se/kg DM) or supranutritional Se (■; 2.9 μg of Se/kg DM) diet for 0, 14, 28, 42, or 56 d before slaughter. Experimental units were four wethers per treatment for each slaughter day, except on d 0, when only four wethers were slaughtered. On d 14, 28, 42, and 56, the Se contents of kidneys, liver, and spleen were greater ($P < 0.001$) in wethers fed supranutritional Se. The regression curves represent the relationship between the organ Se content of individual wethers and total days the supranutritional Se diet was fed.

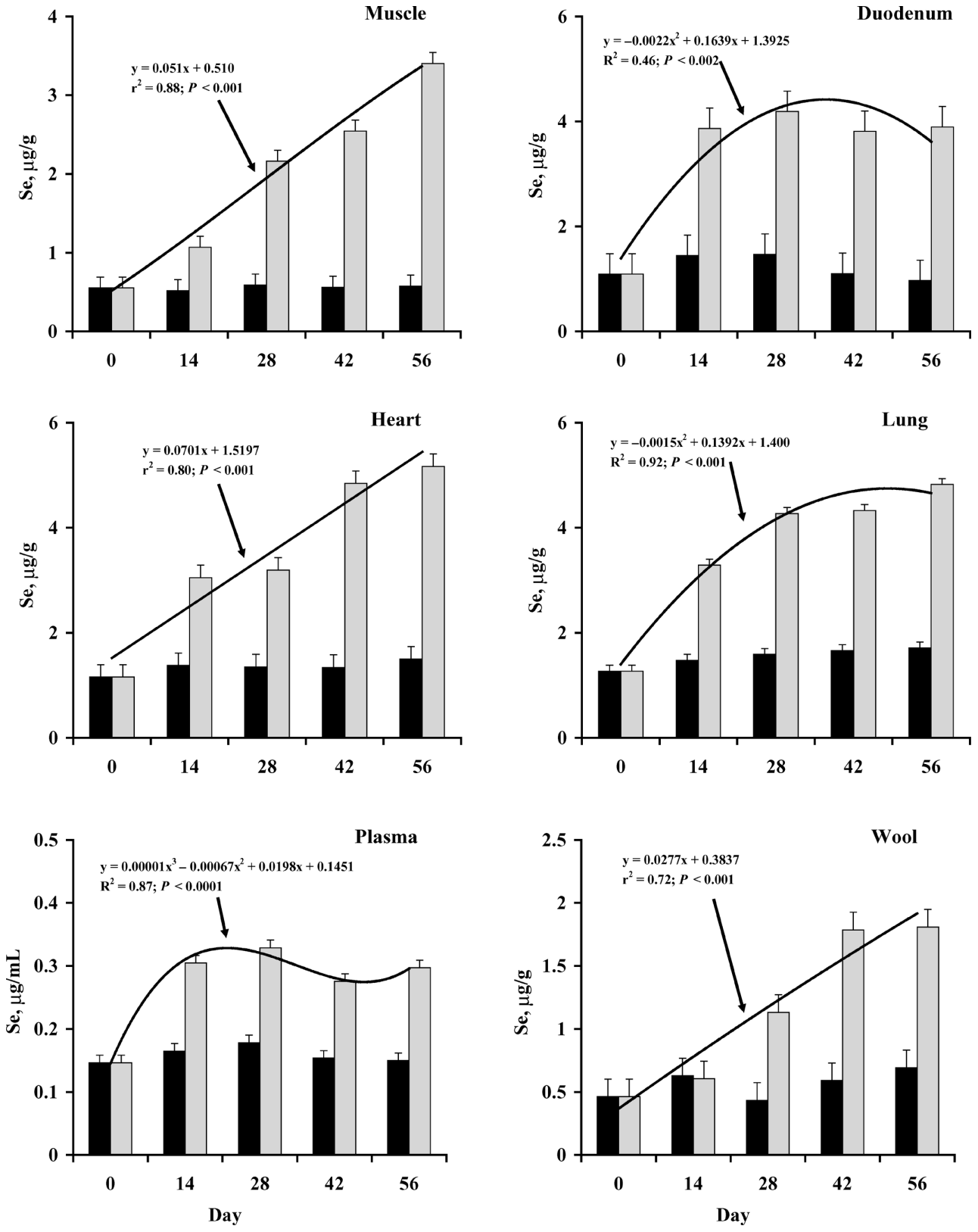

Figure 2. Selenium concentration of muscle, duodenum, heart, lung, plasma, and wool from wether lambs fed an adequate Se (■; 0.2 µg of Se/kg DM) or supranutritional Se (■; 2.9 µg of Se/kg DM) diet for 0, 14, 28, 42, or 56 d. Experimental units were four wethers per treatment per slaughter day, except on d 0, when only four wethers were slaughtered. On d 14, 28, 42, and 56, the Se concentrations of tissues/organs presented were greater ($P < 0.001$) in wethers fed supranutritional Se. Regression curves represent the relationship between organ/tissue Se concentration and days that supranutritional Se was fed.

sequestered in the general protein pool as a methionine-like compound. For that reason, the half-life of Se from selenomethionine is greater than the half-lives of other common chemical forms of dietary Se. Griffiths et al. (1976) estimated that the human female whole-body biological half-life of ^{75}Se from [^{75}Se]selenomethionine was 2.7 times more than ^{75}Se from [^{75}Se]selenite (261 vs. 96 d, respectively). Swanson et al. (1991) suggested that the long half-life of selenomethionine compared with selenite is a result of extensive reutilization/recycling of selenomethionine rather than tissue turnover rates. Interestingly, [^{74}Se]selenomethionine in plasma, liver, and peripheral tissues (e.g., bone, skeletal muscle, kidney) will turn over at a greater rate than [^{74}Se]selenite, but still remain in the body longer. Theoretically, Se sequestration as selenomethionine can only exist until the replacement of methionine with selenomethionine reaches equilibrium (i.e., rate of selenomethionine substitution equals selenomethionine catabolism); furthermore, subsequent release of Se from selenomethionine would be subject to the rate of methionine catabolism. As previously mentioned, Se concentration in skeletal muscle continued to increase in supranutritional Se-fed wethers over the 56-d treatment period. This indicates a greater capacity for muscle Se accumulation in growing wethers fed 2.9 μg of Se·g of $DM^{-1}\cdot d^{-1}$ as high-Se wheat grain beyond 56 d.

Based on the present results and evidence of a long selenomethionine half-life (Griffiths et al., 1976; Swanson et al., 1991), providing supranutritional Se as a high-Se/selenomethionine grain could be used to rapidly increase Se depots in ruminants. Subsequent periods of potential Se deficiency, occurring during long periods of inadequate Se intake, might thereby be ameliorated. In other words, increasing skeletal muscle Se depots would provide a long-term slow release source of Se. In low-Se-status Finnish men, Levander et al. (1983) clearly demonstrated the long-term influences of supranutritional Se fed as high-Se wheat or Se-enriched yeast. These high-selenomethionine sources maintained elevated plasma Se and platelet glutathione peroxidase activity relative to supranutritional sodium selenite long after dietary Se withdrawal.

Available literature indicates that enhancement of long-term Se depots cannot be accomplished with the traditional supplemental Se salts (van Ryssen et al., 1989; Lawler et al., 2004). The supranutritional use of Se salts, as well as Se-enriched yeast, is prohibited (FDA, 2004), and Lawler et al. (2004) demonstrated that sodium selenate, even when fed at nine times the daily Se requirement (NRC, 1996), did not increase muscle Se in steers. Furthermore, van Ryssen et al. (1989) demonstrated that ruminal microorganisms will incorporate supranutritional sodium selenite into selenocysteine but not selenomethionine. Selenocysteine does not replace cysteine during mammalian mRNA translation, and regardless of origin, selenocysteine/-cystine is rapidly catabolized, and the Se is liberated as selenide (Esaki et al., 1982; Hasegawa et al., 1996; Nakamuro et al., 2000). Incorporation of selenocysteine into mammalian selenoproteins (e.g, thioredoxin reductase and glutathione peroxidase) can only occur during a cotranslational event when selenocysteyl-tRNA is formed from a unique seryl-tRNA and selenide (Beilstein and Whanger, 1986; Sunde, 1990; Stadman, 1996). As such, the selenocysteine molecule is not recyclable in ruminants. Collectively, these data indicate the only reasonable way to increase endogenous Se depots in ruminants is through the use of high-selenomethionine feeds.

Feeding supranutritional Se, as high-Se grain, is an efficient means for rapidly enhancing the Se depots in sheep; however, adoption of such a strategy should be viewed with caution. Earlier Se research revealed the potential toxicity that can occur with the use of high-Se grains (Franke and Potter, 1936), and recent research indicated that supranutritional Se (2.0 μg/g), as selenomethionine, may influence rat fetal numbers (Taylor et al., 2005). Furthermore, decreased fetal, fetal membrane, placentome, and placenta weights, and placentome numbers have been reported in pregnant nulliparous ewes consuming 3.0 μg of Se·g of $DM^{-1}\cdot d^{-1}$, as high-Se wheat grain, during the last 90 d of gestation (Ward et al., 2004). Current efforts are underway to verify the effects of short-term feeding of supranutritional organically bound Se in sheep.

The results presented herein address additional applications for the strategic use of high-Se feeds. Hintze et al. (2002) and Lawler et al. (2004) reported that a 100-g portion of beef muscle from animals fed high-Se wheat would provide greater than 200% of the recommended daily requirement of Se for humans. The Se content of the LM taken from wethers fed supranutritional Se in the present study was seven times the Se concentration of uncooked lamb loin (#13159) listed in the USDA (2004) National Nutrient Database for Standard Reference. When adjusted to similar moisture content, a 100-g portion would provide 196 and 250% of the suggested recommended daily Se requirement for male and female humans, respectively (RDA, 1989). The same 100-g portion from the wethers slaughtered after 28 d of supranutritional Se feeding would provide slightly more that 100% of the requirement.

Implications

High-selenium wheat grain can be used strategically to deliver supranutritional selenium to lambs without adversely influencing performance. This type of selenium supplementation strategy could provide sheep with an endogenous selenium source during periods of inadequate selenium intake and increase the selenium content of retail skeletal muscle products.

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